

IN THE UNITED STATES DISTRICT COURT
FOR THE SOUTHERN DISTRICT OF OHIO
WESTERN DIVISION

THE DOW CHEMICAL CO., et al.,)
)
Plaintiffs,)
)
v.)
)
ACME WRECKING CO., INC., et al.,)
)
Defendants.)
)
THE DOW CHEMICAL CO., et al.,)
)
Plaintiffs,)
)
v.)
)
SUN OIL COMPANY, et al.,)
)
Defendants.)
)
UNITED STATES OF AMERICA,)
)
Plaintiff,)
)
v.)
)
AERONCA, INC., et al.,)
)
Defendants.)

EPA Region 5 Records Ctr.



275073

Case Nos. C-1-97-307
C-1-97-308
C-1-01-439

Judge Weber

DEFENDANT AERONCA's DISCLOSURE OF EXPERT TESTIMONY

Defendant Aeronca, Inc., pursuant to the Case Management Order and Rule 26(a)(2), Rules of Civil Procedure, hereby informs the parties the William J. Deutsch will provide expert testimony in this matter. Attached hereto is the report of Mr. Deutsch and the additional information required by Rule 26(a)(2)(B).

CERTIFICATE OF SERVICE

I hereby certify that a copy of the foregoing was sent by first class United States mail, postage prepaid, this 6th day of November, 2002, to the following:

Annette M. Lang (also via fax)
Environmental Enforcement Section
Department of Justice
P.O. Box 7611
Ben Franklin Station
Washington, D.C. 20044

Michael J. O'Callaghan (also via fax)
Shumaker, Loop & Kendrick
41 S. High St.
Columbus, Ohio 43215

Jonathon Conte
Blank, Rome, Comisky and McCauley
PNC Center
201 E. Fifth St., Suite 1700
Cincinnati, Ohio 45202

John H. Phillips
Phillips Law Firm
9521 Montgomery Rd.
Cincinnati, Ohio 45242

Gary F. Franke
Attorney at law
120 E. Fourth St., Suite 560
Cincinnati, Ohio 45202


David E. Northrop

Geochemistry Services

2414 Alexander Ave.
Richland, WA 99352

phone 509-375-6100

Occurrence, Geochemistry and Fate of Manganese

Skinner Landfill, West Chester, Ohio



Prepared by:

William J. Deutsch

Geochemistry Services

Prepared for:

Porter Wright Morris & Arthur LLP

41 South High Street

Columbus, OH 43215-6194

October 16, 2002

Occurrence, Geochemistry and Fate of Manganese Skinner Landfill, West Chester, Ohio

The purpose of this report is to present information and opinions regarding the occurrence, geochemistry and fate of manganese at the Skinner Landfill, West Chester, Ohio. This report is based on my twenty-three years experience as a groundwater geochemist and review of the technical data and other information you have provided, including but not limited to the material identified in Exhibit A.

Introduction

Manganese is a naturally occurring metal that is common in soil, sediment, groundwater and surface water. Permanganate (MnO_4^-), the highly oxidized form of manganese, is used as a cleaning agent for metals. At an industrial facility operated by Aeronca, Inc. in Middletown, Ohio, a solution containing potassium permanganate was used in a cleaning bath for stainless steel parts. It is alleged that spent cleaning solution containing residual potassium permanganate and its byproducts (described below) was sent to the Skinner Landfill for disposal. The landfill was used for the disposal of municipal refuse for approximately 56 years (1934 – 1990). As early as 1964, industrial wastes were also accepted for disposal. This landfill is now on the National Priorities List for cleanup because of contamination of soil and water by a wide variety of organic and inorganic compounds. The site has been characterized by Phase I and Phase II Remedial Investigations conducted by Roy F. Weston, Inc. (1989) and WW Engineering & Sciences Inc. (1991), respectively.

Manganese has been identified as one of the contaminants of potential concern in groundwater and the surface water of Skinner Creek. The source(s) of manganese in these waters may be either (or both) naturally occurring or landfill-disposed manganese. The occurrence of elevated manganese in groundwater and surface water is a function of the geochemistry of manganese and the local environmental conditions. This report discusses the following topics as they apply to manganese and the Skinner Landfill:

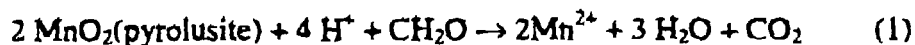
- Manganese Geochemistry
- Impact of Landfills on Manganese Mobility
- Occurrence of Manganese at the Skinner Landfill
- Potassium Permanganate Chemistry, Uses and Byproducts
- Fate of Potassium Permanganate in the Landfill Environment
- Is Potassium Permanganate Likely to Increase/Decrease Manganese Concentrations in Groundwater and/or Surface Water

The final section of this report is a summary of these topics and provides conclusions relative to the contribution of disposed permanganate waste to the occurrence of manganese contamination at a level of concern at the Skinner Landfill.

Manganese Geochemistry

Manganese is a common minor element in soil with a normal range in concentration of 20 to 3,000 mg/kg (Lindsay 1979). It is redox-sensitive and occurs naturally in the

environment in three valence states: Mn(II), Mn(III), and Mn(IV). [The valence state of an element reflects the electrical charge on the species of the element; for example Mn(II) is the +2 charge species of manganese. The higher the charge, or valence, the more oxidized the element; and the lower the charge, the more reduced the element.] Common manganese minerals that form from each of its naturally-occurring valence states are: Mn(II) - rhodochrosite (MnCO_3); Mn(III) - manganite ($\gamma\text{-MnOOH}$); and Mn(IV) - pyrolusite ($\beta\text{-MnO}_2$). It has been shown that microorganisms can obtain energy by the oxidation of organic matter to carbon dioxide with Mn(IV) as the sole electron acceptor (Lovley 1991). The source of Mn(IV) in an aquifer is the minerals, such as pyrolusite, that contain this valence state of the element. The oxidation/reduction process for pyrolusite can be represented by the following reaction:



where CH_2O (carbohydrate) is used to represent organic compounds, which are oxidized by Mn(IV) in MnO_2 . The Mn^{2+} released to solution by this reaction may partially precipitate under reducing conditions (that is, conditions that favor the lower valence state species of manganese) as rhodochrosite according to:



The resulting dissolved concentration of manganese in equilibrium with the manganese mineral will be a function of many factors including groundwater pH, Eh, carbonate concentrations and ionic strength, however rhodochrosite is generally more soluble than pyrolusite, thus the dissolved Mn concentration will be higher in groundwater limited by rhodochrosite formation than one limited by pyrolusite formation. [Eh is a measure of the redox potential of the aquifer. A low Eh reflects reducing conditions that favor lower valence states of manganese, while a high Eh reflects oxidizing conditions and favors higher valence states.] Typical oxidizing groundwater conditions (pH = 7, Eh > 600 mV) result in pyrolusite limiting dissolved manganese to less than 0.05 mg/L, whereas typical reducing groundwater conditions (pH = 7, Eh < 400 mV) result in rhodochrosite limiting dissolved manganese in the range of 5.5 to 30 mg/L (Lindsay 1979).

Reoxidation of a groundwater with high dissolved Mn^{2+} commonly leads first to the formation of an Mn^{3+} mineral (Eary and Schramke 1990) by reactions of the type:



The solubility of MnOOH may be 100x less than that of MnCO_3 under the more oxidizing conditions, consequently the dissolved Mn^{2+} concentration may be on the order of 0.05 mg/L when limited by MnOOH under oxidizing conditions.

As a consequence of the above redox reactions, the dissolved manganese concentration is controlled by natural site conditions and the formation of stable manganese minerals, which have different solubilities depending on the site conditions. Application of these geochemical processes to the landfill environment is discussed next.

Impact of Landfills on Manganese Mobility

A landfill is a source of reactive organic matter like the carbohydrate that reduced pyrolusite in reaction (1) above. Because of this, placing a landfill on a typical oxidized soil creates a localized reducing condition that commonly dissolves manganese minerals in the soil as the landfill leachate moves through the subsurface. This leads to elevated manganese concentrations in groundwater beneath and immediately downgradient of the landfill (Deutsch 1997). As the groundwater flows away from the landfill and reoxidizes, dissolved manganese concentrations decrease due to physical dispersion processes and the geochemical process of mineral formation described above (reaction 3).

Several examples of manganese geochemistry at landfills have been published. Baedecker and Back (1979) showed that at the Army Creek landfill in Delaware dissolved manganese increased from less than 0.01 mg/L under background conditions to 4.2 mg/L adjacent to the landfill. Downgradient of the landfill, the concentration began to decrease and it had returned to background about 800m from the landfill. Baedecker and Apgar (1984) described the geochemical processes active at the Army Creek landfill and noted the presence of the reduced Mn mineral rhodochrosite adjacent to the landfill and an oxidized MnO₂ mineral farther downgradient. They equated the reducing conditions at the landfill to the degradation of landfill organic matter. Nicholson et al. (1983) found a similar situation at the Borden landfill (Ontario, Canada) where the background Mn concentration was 0.28 mg/L and the concentration in the plume downgradient of the landfill was 11 mg/L. They also discuss the change in redox condition along the flow path and the manganese minerals that control dissolved Mn concentrations.

Mirecki and Parks (1994) studied the Shelby County landfill (Memphis, Tennessee) and found that the average Mn in background wells in the alluvial aquifer was 0.185 mg/L; whereas in the wells downgradient of the landfill it was 2.5 mg/L. The redox potential was very reducing at about 0 mV near the landfill and it was more oxidizing downgradient. Nielsen et al. (1995) measured the following dissolved Mn concentrations associated with the Vejen City landfill (Jutland, Denmark):

landfill perimeter - 5.7 mg/l;
135m downgradient - 0.67 mg/L;
250m downgradient - 0.46;
350m downgradient - <0.1 mg/L.

Deutsch (1997) discusses Mn mobility at the Fort Lewis (Washington) landfill where the dissolved Mn increases to 11 mg/L due to the influence of landfill leachate, but the concentration returns to background (<0.05 mg/L) 650m downgradient of the landfill. At this site, the landfill depressed the pH to 6.25 from a background value of 7.25. Downgradient of the landfill, the pH increased to background over the distance required for manganese mineral formation.

The mobilization of manganese by organic matter has also been shown for conditions other than found at landfills. At a crude oil spill site in Minnesota, dissolved Mn

increases from < 0.03 mg/L upgradient of the spill to 6.6 mg/L in the vicinity of the product floating on the water table. In this case, the reducing conditions are produced by the soluble, oxidizable components of the crude oil that dissolve into the groundwater. As the groundwater naturally reoxidizes downgradient of the spill site, the dissolved Mn concentration returns to background within 100 to 150 meters of the source (Baedecker et al. 1993). Note that the soluble components of petroleum hydrocarbon include benzene, ethylbenzene and toluene, which are present at high concentrations in the waste lagoon sediments and groundwater at the Skinner Landfill. These compounds were also found in drums near the waste lagoon and landfill (WWES 1992).

Occurrence of Manganese at the Skinner Landfill

The concentrations of manganese have been characterized during the Skinner Landfill Remedial Investigation for a wide variety of media (groundwater, surface water, soil and sediment). This section discusses the concentration ranges relative to background levels. The background concentrations were measured in media unaffected by the landfill.

Groundwater

Groundwater beneath the Skinner Landfill flows in a shallow aquifer comprised of unconsolidated sand and gravel deposits. Underlying this shallow aquifer is the bedrock aquifer. Groundwater samples were collected and analyzed for potential organic and inorganic contaminants from 39 monitoring wells installed in the two aquifers. Table 2-4 of the Baseline Risk Assessment lists the manganese range of detections in groundwater as 0.0104 to 18 mg/L with a background concentration range of 0.021 to 0.712 mg/L. The higher levels of manganese concentration in impacted groundwater are consistent with the solubility of manganese minerals affected by leachate from a landfill described above.

Surface Water

Surface waters were collected and analyzed from Mill Creek, Skinner Creek, Dump Creek, Diving Pond and Trilobite Pond. As shown in Table 2-1 of the Baseline Risk Assessment, manganese was not considered a contaminant of concern in any of these locations, except one, because its concentration was similar to background values. The one exception is Skinner Creek surface water where manganese concentration was measured in the range of 0.0163 to 0.0715 mg/L (Table 2-5, Baseline Risk Assessment), which was considered elevated compared to the background manganese concentration of 0.0094 mg/L for the creek.

Soil

Sixty-two soil samples were collected in the vicinity of the buried waste lagoon and analyzed for a wide variety of potential contaminants, including manganese. The range of detected manganese concentrations in soil near the waste lagoon is 168 to 2,430 mg/kg (Phase II RI Table 5.3). Seven soil samples were collected in the vicinity of the buried pit and analyzed for manganese. The range of detected manganese concentrations in soil

near the buried pit is 639 to 3,630 mg/kg (Phase II RI Table 5.4). Nineteen additional soil samples were collected and analyzed for manganese from monitoring well boreholes throughout the site. The range of detected manganese soil concentrations from these samples is 337 to 1,830 mg/kg (Phase II RI Table 5.5). The range of background concentrations for manganese in soil has been reported as 542 to 1,180 mg/kg (Phase II RI Table 5.3, 5.4 and 5.5). Manganese was not considered a chemical of concern for soil in the Baseline Risk Assessment when the measured soil concentrations were compared to this background range (Baseline Risk Assessment Table 2-1).

Sediment

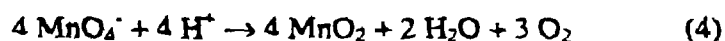
Sediment samples from three creeks, three ponds and three leachate seeps associated with the site were collected and analyzed. The range of manganese concentrations for the 32 sediment samples is 470 to 3,520 mg/kg (Phase II RI Table 5.13, 5.15, 5.17 and 5.19). The range of background concentrations for manganese in sediment has been reported as 805 to 3,250 mg/kg (Phase II RI Table 5.13, 5.15, 5.17 and 5.19). Manganese is not considered a chemical of concern for sediments based on a comparison with background levels (Baseline Risk Assessment Table 2-1).

Summary of Manganese Detections

Based on the sampling described above, manganese is only considered elevated in groundwater and Skinner Creek surface water. Skinner Creek may be partially fed by groundwater with elevated dissolved manganese. The other surface water bodies at the site and the soil and sediment are not considered to be contaminated with manganese.

Potassium Permanganate Chemistry, Uses and Byproducts

Manganese in permanganate (MnO_4^-) is in the +7 valence state [Mn(VII)]. This is not a naturally occurring valence state for manganese. Permanganate is produced by an industrial process for the purpose of creating a strong oxidizing agent. Mn(VII) is not a thermodynamically stable form of manganese, and it will slowly oxidize water with the evolution of oxygen:



In this oxidation-reduction reaction Mn(VII) in the permanganate ion is reduced to Mn(IV) and it forms the stable +4 manganese mineral pyrolusite.

Potassium permanganate is a strong oxidant that has been used for approximately 100 years in the drinking water, wastewater and chemical manufacturing industries. [An oxidant is a chemical compound that has the ability to raise the valence state (oxidize) a contaminant. For example, hydrogen sulfide is a contaminant in which sulfur is in the -2 valence state. An oxidant will oxidize this sulfur to the +6 valence state and change the hydrogen sulfide contaminant to the relatively benign sulfate compound.] In potable water it is used to control taste and odor problems by oxidizing iron, manganese and hydrogen sulfide. In the wastewater field, it is used to oxidize hydrogen sulfide and other

odor causing compounds, prevent corrosion, and destroy phenol and other toxic pollutants. In the manufacturing industry it is used for metals surface treatment and equipment cleaning. This was the application of permanganate at the Aeronca plant in Middletown.

Rather than being considered a source of groundwater contamination, potassium permanganate has been identified, tested and used as a reagent to treat groundwater contaminated with organic contaminants. The strong oxidizing ability of permanganate is used to oxidize the carbon in the organic compounds to carbon dioxide and decompose the contaminant to innocuous inorganic compounds. For example, potassium permanganate has been emplaced in the aquifer at the Portsmouth Gaseous Diffusion plant in central Ohio to test its ability to oxidize trichloroethylene (TCE) that is contaminating the groundwater (Siegrist, Lowe et al. 1999). The oxidation of TCE (C_2HCl_3) by permanganate can be represented by the reaction:



At the recent Battelle Conference on Remediation of Chlorinated and Recalcitrant Compounds (May 20-23, 2002; Monterey, California), at least 18 papers were presented on the use of permanganate for aquifer remediation and an entire session was devoted to permanganate oxidation of organic compounds.

The primary manganese byproducts of permanganate are the manganese minerals describe above (pyrolusite, manganite and rhodochrosite). The type of natural manganese solid that forms in the environment depends on the pH, redox state and concentrations of other ions in the groundwater or surface water. The resulting dissolved concentration of manganese is a functioning of the solubility of the manganese solid in the environment.

Fate of Potassium Permanganate in the Landfill Environment

As discussed above, it is alleged that spent cleaning solution containing residual potassium permanganate and its byproducts was sent to the Skinner Landfill for disposal. Reaction (4) shows that the primary manganese byproduct of permanganate decomposition is manganese dioxide, MnO_2 . The disposal of MnO_2 in the landfill adds to the natural concentration of manganese in the soil, which is likely present as MnO_2 and/or $MnOOH$. The effect on groundwater concentration of adding additional MnO_2 to the soil is discussed in the following section. The residual permanganate added to the landfill produces reduction/oxidation (redox) reactions because of the strong oxidizing ability of this compound.

Redox reactions require that one compound be oxidized while another is being reduced. The addition of an oxidizing agent, like permanganate, to a landfill environment with reduced organic compounds, such as benzene and toluene, produces redox reactions. The Remedial Investigation reports document the presence of oxidizable organic compounds in the soil and groundwater at the landfill. A representative redox reaction between organic compounds and permanganate is benzene (C_6H_6) oxidation:



In this reaction, carbon is oxidized from the -1 valence state in benzene to the +4 valence state in HCO_3^- (bicarbonate) as manganese is reduced from the +7 valence state in permanganate to the +4 valence state in MnO_2 . Permanganate thus oxidizes many of the organic contaminants co-disposed in the landfill producing innocuous, inorganic forms of carbon such as bicarbonate. This is the same process that occurs when permanganate is used as a remediation agent for organic compounds described above. The manganese that is reduced forms the solid MnO_2 or some other manganese solid (MnOOH or MnCO_3) depending on the final pH and Eh of the environment.

Is Potassium Permanganate Likely to Increase/Decrease Manganese Concentrations in Groundwater and/or Surface Water

The dissolved manganese concentration in groundwater or surface water is a function of the solubility of the manganese mineral that is limiting the dissolved level. As discussed above, manganese is a redox-sensitive element and at normal environmental pH values the solubilities of its minerals are primarily a function of the redox potential of the environment. Under relatively oxidizing Eh conditions (> 600 mV), pyrolusite (MnO_2) limits dissolved manganese to low concentrations typically less than 0.05 mg/L, while under relatively reducing Eh conditions (< 400 mV) rhodochrosite (MnCO_3) limits the dissolved manganese concentration, but at relatively high levels of about 5 to 30 mg/L. As a consequence, because the dissolved concentration of manganese in groundwater or surface water is limited by the formation of these reaction products, the concentration in water has little to do with the amount of manganese solids in the soil or sediment. As long as a mineral is effectively limiting the dissolved manganese concentration, adding or removing the mineral containing the element from the solid phase will not affect the dissolved concentration. Consequently, the addition of permanganate and its byproduct manganese minerals to the landfill will not directly affect the concentration of manganese in the groundwater or surface water, except as it affects the Eh of the environment.

Because permanganate is a strong oxidizing agent, it will tend to raise the Eh of the environment. This will favor the formation of the byproduct manganese minerals pyrolusite or manganite over rhodochrosite, which will limit the dissolved manganese to lower levels. However, if the reducing capacity of the environment is greater than the oxidizing capacity of the permanganate, then the Eh of the environment may not be raised by the addition of permanganate. This is the typical condition in a landfill or waste lagoon with large quantities of organic matter, which acts as a reducing agent. Where there is more reducing agent than oxidizing agent, the result will be that the system becomes reducing and the Eh is depressed. This is the case at the Skinner Landfill. Although the Eh was not measured during the investigations at the landfill, the dissolved iron concentrations were determined. Dissolved iron can be used to estimate Eh conditions, because iron concentrations are low under oxidizing conditions and high under reducing conditions at normal groundwater pH values. Iron was detected in the range of 4.23 to 19 mg/L in the contaminated sand and gravel aquifer monitoring wells compared to a background range of 0.009 to 0.018 mg/L. This strongly suggests that the

landfill has generated reducing conditions in the groundwater. The elevated manganese in the water is not a result of the permanganate or its byproduct manganese minerals added to the landfill, but is a response to the reducing environment created by the organic matter disposed in the landfill. The addition of permanganate to the landfill would work to reduce the dissolved manganese level in water because of its potential to make conditions more oxidizing.

Summary and Conclusions

Spent permanganate cleaning solution was allegedly disposed of at the Skinner Landfill. The Remedial Investigation conducted at the landfill showed elevated dissolved manganese in groundwater beneath and downgradient of the landfill and Skinner Creek surface water, but manganese concentrations were not elevated in soil, sediment or other surface waters.

Manganese is a reactive element in the environment. Under oxidizing conditions found in most shallow groundwaters, mineral formation will limit dissolved Mn to low dissolved concentrations (<0.05 mg/L). If reducing conditions are imposed on the natural system by a landfill or other source of oxidizable organic matter, the Mn minerals will become more soluble and will maintain a higher level (tens of mg/L) of dissolved Mn in groundwater.

The manganese in permanganate is in the highly oxidized +7 valence state making permanganate a strong oxidizing agent, which is used in many commercial applications including groundwater treatment. The byproducts of permanganate oxidation are the relatively oxidizing manganese minerals, such as pyrolusite and manganite. The disposal of permanganate and its byproduct manganese minerals at a landfill would tend to counter the reducing ability of the co-disposed organic contaminants thereby making the system less reducing. This would lower rather than raise the dissolved manganese concentrations in groundwater and surface waters impacted by the landfill.

The elevated manganese in groundwater and surface water at the Skinner Landfill is a result of the reducing reactions between disposed organic compounds and the naturally occurring manganese minerals in the soil and sediment. The addition of permanganate and its byproducts to the Skinner Landfill does not produce the elevated dissolved manganese levels, and may actually lower manganese concentrations in groundwater and surface water.

Exhibit A

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U.S Environmental Protection Agency, Region V. Record of Decision, Skinner Landfill, West Chester, Butler County. Union Township, Ohio. June 4, 1993. (not Bates numbered)

WW Engineering & Science, Inc. (WWES). Phase II Remedial Investigation of the Skinner Landfill Site, West Chester, Ohio. May 1991. (Bates Nos. EPA 17684 through EPA 18388)

WW Engineering & Science, Inc. (WWES). Baseline Risk Assessment for the Skinner Landfill Site, West Chester, Ohio. June 1991. (Bates Nos. EPA 18394 through EPA 18965)

WW Engineering & Science, Inc. (WWES). Feasibility Study for the Skinner Landfill Site, West Chester, Ohio. April 1992. (Bates Nos. 002844 through 003259)

Resume

William J. Deutsch

AREAS OF EXPERTISE

- Geochemistry
- Hydrogeology
- Geochemical Modeling
- Remedial Investigation/
Feasibility Studies
- Landfill Investigations

EDUCATION

University of
Washington: M.S.,
Geological Sciences,
1978

Scripps Institute of
Oceanography:
Graduate Studies,
1974-1975

University of
Washington: B.S.,
Geological Sciences,
1970

University of
Washington: B.S.,
Oceanography, 1970

PROFESSIONAL HISTORY

Battelle

Staff Scientist

2002- present

Geochemistry Services

Consultant

1999-2002

URS (part time)

Senior Geochemist

1999-2002

REPRESENTATIVE EXPERIENCE

Mr. Deutsch has 25 years of experience in geology and geochemistry. His technical specialty is low-temperature aqueous geochemistry applied to water/rock interactions, geochemical modeling, and aquifer protection/restoration. He has planned, directed, and participated in numerous laboratory and field programs dealing with site characterization, aquifer chemical interactions, geochemical modeling, and groundwater protection/restoration. He teaches introductory courses in groundwater chemistry and geochemical modeling for the National Ground Water Association and other professional organizations. His book titled *Groundwater Geochemistry* was published in 1997 by CRC Press. Specific experience includes:

Site Investigations

- Remedial Investigation, Maine Department of Environmental Protection, Blue Hill Mine Site, Maine. Review and evaluate RI Report for this former Zn-Cu copper mine that is generating acid mine drainage from the tailings and disposed mine rock. Provide geochemical expertise in the selection of an appropriate remediation technique.
- Well Field Program, City of Portland, Oregon. Augmented hydrologic methods with geochemical techniques, such as stable isotope data (H/D and $^{18}\text{O}/^{16}\text{O}$) and plotting water composition on trilinear diagrams, to evaluate sources of recharge to groundwater and surface water bodies
- Water Resources Assessment, Sierra Pacific Resources, Thousand Springs Valley, Northeast Nevada. Responsible for geochemistry component of a program to evaluate the quantity and quality of groundwater and surface water in a 400-square-mile basin. Tasks included compiling spring water and well water data for over 100 sampling locations; evaluating existing geochemical system from major ion and stable isotope data, and predicting the impact of groundwater production on the geochemical system.
- Mine Development, confidential client, New Zealand. Evaluated expected pit lake water chemistry from a proposed open pit gold mine. Used the geochemical modeling codes PHREEQE and MINTEQA to simulate the mixing and chemical reactions of several water types (runoff, rainfall and groundwater) in the pit. Estimated the expected water composition of the lake for comparison with regulatory standards.
- Geochemical Model Development, confidential client, Salt Lake City, Utah. Developed a conceptual water-rock model and a MINTEQA-based chemical reaction model of site affected by low pH leachate from a reservoir and mine tailings area. The geochemical model was used with a transport model developed by others to

William J. Deutsch

URS Woodward-Clyde

Seattle
Operations/Program
Manager. 1992-1999

Associate and
Senior Project
Hydrogeochemist.
1987-1992

Jacobs Engineering,
Inc.. Senior Geochemist
and Acting Hydrology
Task Manager. 1985-
1987

Battelle Northwest,
Scientist through Senior
Research Scientist,
1979-1985

U S. Navy,
Oceanographic
Research Officer and
Executive Officer,
1970-1974

REGISTRATIONS

Certified Groundwater
Professional
(NGWA #506)

AFFILIATIONS

National Ground Water
Association

American Chemical
Society

simulate the long-term effect of the leachate on groundwater quality and to evaluate remedial alternatives.

- East Gate Disposal Yard Expanded Site Investigation, USACE, Fort Lewis, Washington. Project Manager and lead technical resource for investigation. This disposal yard was used for many years to dispose of spent solvents and used petroleum products generated at vehicle maintenance facilities. A plume of chlorinated solvent groundwater contamination extended several miles downgradient of the disposal yard. This investigation focused on identifying and characterizing dense nonaqueous phase liquids (DNAPLs) in the aquifer that are continuing sources of groundwater contamination. Soil, groundwater, and vapor samples were collected using trenching, drivepoint, soil boring and monitoring well methods.
- Vancouver Barracks Site Inspection, USACE, Vancouver, Washington. Project Manager for this site inspection, which was conducted under Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) guidelines. Soil sampling conducted at former maintenance facilities and underground storage tank (UST) locations to evaluate the presence of contamination. Samples analyzed for all compounds in the CERCLA Target Analyte List and Target Compound List. Recommended removing site from consideration for the National Priorities List.
- Greenacres Landfill Remedial Investigation/Feasibility Study (RI/FS), Spokane County, Spokane, Washington. Project Manager responsible for completion of RI report and direction of FS at this Superfund site. Primary considerations included groundwater contaminated with organic and inorganic compounds. Presented RI/FS results at public information meeting.
- Resource Conservation and Recovery Act (RCRA) Closures, Western Farm Service, eastern Washington. This project included evaluation of five sites for residual soil/water pesticide contamination produced by past operating practices. As Project Manager, responsible for developing sampling and analysis plans, oversight of sampling activities, and preparation of closure plans.
- Fort Lewis Landfill No. 5 RI/FS, USACE, Fort Lewis, Washington. Project Manager for RI at this Superfund landfill site. This effort involved the development of a Comprehensive Work Plan and detailed Sampling and Analysis Plan. The study included a geophysical survey; waste characterization; and hydrogeologic investigation consisting of the installation of monitoring wells, pump tests, aquifer characterization, and water sampling and analysis of monitoring wells and surface water locations. Presented results of studies at a public information meeting. RI and risk assessments supported a No Action Record of Decision, which was signed in July 1992.
- Responsible for technical development of a prototype metal speciation and computer simulation model for the U S. Environmental Protection Agency. This project included testing existing geochemical codes and developing methodologies linking a geochemical code with a flow code.
- Factory Lane Site Investigation, Rhone-Poulenc, Middlesex, New

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Jersey. Evaluated the fate and transport of arsenic in soil and groundwater at this facility. Developed procedures for estimating the importance of geochemical retardation of arsenic during transport by groundwater.

- Part B Permit Applications, confidential client, Casmalia, California. Prepared soil and groundwater geochemistry sections for RCRA Part B applications and California solid waste assessment reports. Conducted characterization studies of hazardous waste facilities containing metals, acids, solvents, herbicides, pesticides, polychlorinated biphenyls (PCBs), and other organic and inorganic materials. For monitoring purposes at these sites, wrote and contributed to groundwater, surface water, and vadose zone monitoring plans as well as sampling and analysis plans.
- Phase I Real Estate Transaction Audits, PureGro Company, Sacramento, California. Project Manager for audits conducted at facilities in Washington, Oregon and Idaho. Projects consisted of records review, facility walk-throughs, interviews and a report of findings. Follow-on soil remediation for pesticides and hydrocarbons conducted at several sites.
- Site Assessment and Remedial Design, Chevron-Chemical, various sites in Washington and Oregon. Pacific Northwest Site Manager for work conducted at three nitrogen fertilizer plants with elevated levels of nitrogen (nitrate and ammonia) in soil and groundwater. Site characterization and groundwater modeling conducted at each facility to develop appropriate remedial alternatives for soil flushing and groundwater extraction.
- Fort Lewis Logistics Center Site Investigation, Washington. Project Manager for this sampling, analysis, and evaluation project to identify sources of trichloroethene contamination in the Vashon Drift and Salmon Springs Aquifers at the Logistics Center. Detected product in groundwater at a former drum disposal area and recommended further characterization work to locate pure phase contamination in the aquifer. Also conducted an extensive soil survey to evaluate the possible presence of lead and PCB contamination in the material recycling yard.

Site Remediation

- Remedial Design, former phosphate plant, Corroco, Charleston, South Carolina. Conceptual design and oversight of treatability testing for site with lead and arsenic groundwater contamination at pH values less than 1. Arsenic remediation by iron mineral precipitation and adsorption. Lead removal from groundwater by neutralization and mineral precipitation.
- Treatability Test, Industrial Landfill, Winthrop, Maine. Designed and conducted bench-scale test of Oxygen Release Compound to remove elevated arsenic and iron from groundwater. Dissolved concentrations reduced to below detection limits.
- Focused Feasibility Study (FFS), Dupont, Newport, Delaware. Provided geochemistry/hydrogeology expertise for the development of an FFS at former paint production facility. Evaluated the fate and transport of lead, barium, cadmium, and zinc in the subsurface. Performed simulations of soil and

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groundwater remediation of the site for these metals.

- **Model Development and Treatment System Assessment**, confidential client, Henderson, Nevada. Simulated the effect of mineral precipitation from groundwater injected into a treatment unit. Quantified the amount of precipitate anticipated and calculated the amount of acid required to eliminate precipitation of carbonate minerals. Results of simulation verified by bench-scale tests conducted by others.
- **Remediation Design**, Vineland Chemical Company, New Jersey. Developed and implemented geochemical sampling plan to support remedial design for arsenic contaminated soil and groundwater. A geochemical model that included water/rock processes affecting arsenic migration at the site was developed and used to evaluate and enhance proposed remediation techniques.
- **Westinghouse-Hanford In-Situ Remediation Plan**, Richland, Washington. Prepared an updated project plan for conducting bench-scale and pilot scale testing of in-situ methods for remediation of chromium contamination in soil and groundwater at the Hanford site. Proposed methods for testing the fixation of chromium in place, using various chemical reductants to change the redox state and solubility of chromium. Also evaluated and recommended adding iron oxyhydroxides to the system to scavenge mobile chromium and fix it in the solid phase. Discussed the use of geochemical models to aid in the design of the tests and interpretation of the results.
- **Air Sparging Evaluation**, USACE, Hastings, Nebraska. Used site groundwater data and the geochemical modeling code MINTEQA2 to evaluate the amount of mineral precipitation that would occur during air sparging of groundwater contaminated with volatile organic compounds. Recommended methods for minimizing maintenance costs resulting from mineral precipitation.
- **Uranium Mill Tailings Remedial Action (UMTRA)**, U.S. Department of Energy. As the Senior Geochemist on the project, responsible for the technical evaluation of the migration of contaminants associated with seepage from the mill tailings piles into the underlying soil and aquifer systems. Designed aquifer protection systems and developed alternative methods of restoration for affected aquifers at the mill sites.
- For three years at Battelle, managed a project sponsored by the Nuclear Regulatory Commission that evaluated methods for minimizing groundwater contamination from in situ leach uranium mining operations.

Environmental Compliance

- **Environmental Compliance Assessment Surveys (ECAS)**, USACE, Alaska. Project Manager for ECAS work at Forts Richardson, Wainwright, and Greeley in Alaska. Project included compliance surveys of more than 100 facilities on the three bases, and developing findings and recommendations for improving

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operations.

- Pollution Prevention Initiative, USACE, various locations. Project Manager for an evaluation of hazardous materials handling and waste disposal practices at Army reserve bases in Washington, Oregon and California. Projects include development of Pollution Prevention Plans; Spill Prevention, Control, and Countermeasure Plans; and Installation Spill Contingency Plans. Computer software is also being developed for a hazardous materials database.

Training

- Lead Instructor for the Woodward-Clyde "Remediation by Natural Attenuation" seminar, which describes natural attenuation processes in the environment, data collection requirements, model applications, and regulatory compliance. This seminar has been presented fourteen times nationwide in the past few years.
- Presented the Introduction to Groundwater Geochemistry class over 50 times since 1987 to approximately 2,000 professionals in the National Ground Water Association.
- Developed and taught a groundwater geochemical modeling class through the National Ground Water Association and other professional associations five times since 1990. This course features the computer codes MINTEQA2, PHREEQC and BALANCE.
- Presented two, multi-day classes to the Maine Department of Environmental Protection on groundwater geochemistry and geochemical modeling.
- On four occasions presented the geochemistry portion of a groundwater hydrology class held for Bureau of Land Management employees. Described groundwater chemical characterization and the geochemistry of contamination and remediation.
- On two occasions taught general groundwater geochemistry and metals geochemistry short courses to DuPont Corporate Remediation Group.

Public Involvement

- Invited member of the Fate and Transport subcommittee to the Science Advisory Board of the Washington State Department of Ecology (Ecology). The subcommittee provides advice to Ecology on technical issues such as soil and groundwater cleanup levels.
- Wrote the draft Proposed Plan for the Landfill No. 5 Superfund site at Fort Lewis, Washington. Presented the technical information on the Proposed Plan at the public meeting.
- Presented the technical background at the public meeting for the Cleanup Action Plan at the Greenacres Landfill, Spokane, Washington Superfund site.
- Described the technical aspects of the site investigation and long-term monitoring at the Greenacres Landfill Spokane, Washington for the Ecology Technical Advisory Committee public meeting.

Project/Program Management

- U.S. Army Corps of Engineers Indefinite Delivery Contract. Contract Manager for three consecutive, three-year, \$4M per year

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contracts. Delivery orders have included remedial designs for an explosives washout lagoon, removal/replacement of USTs, site investigations, RI/FSs, stormwater plans, real estate assessments, and characterization/permit of hazardous materials from remote sites. Over 75 individual projects have been performed under these contracts

- Served as the acting Manager of Hydrology at the Jacobs Engineering Albuquerque Operations Office. Responsible for the supervision and direction of a team of 13 hydrologists, hydrogeologists, and geochemists on the UMTRA Project. In addition, responsible for technical planning and implementation of hydrogeologic characterization studies, water resource evaluations, contaminant migration analyses, and design of remedial action plans for water resource protection.
- Spent six years as a research scientist at Battelle's Pacific Northwest Laboratory in Richland, Washington. Managed a project sponsored by the U.S. Environmental Protection Agency that improved methods of modeling the movement of contaminated water through soil and sediment. The thermodynamic database of a geochemical modeling code was enhanced by adding elements that are potential groundwater contaminants at some waste sites. Instructed EPA in the proper method for developing realistic chemical models of representative aquifer systems.

Resume

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PUBLICATIONS, REPORTS AND PRESENTATIONS

Mr. Deutsch has authored or co-authored numerous papers dealing with groundwater chemistry and aquifer restoration. A complete list of publications is included below.

Deutsch, W.J. 2002. Redox Processes in Inorganic Remediation. Proceedings of Workshop on Monitoring Oxidation-Reduction Processes in Ground-Water Restoration ed. by R. T. Wilkin, R. D. Ludwig and R.G. Ford. EPA/600/R-02/002 U.S. Environmental Protection Agency. pages 49-52.

Deutsch, W.J. 2000. Geochemistry. In Standard Handbook of Environmental Science, Health, and Technology, ed. by J. H. Lehr, McGraw-Hill New York

Deutsch, W.J. 2000. Geochemical Modeling. In Standard Handbook of Environmental Science, Health, and Technology, ed. by J. H. Lehr, McGraw-Hill New York.

Deutsch, W.J. 1997. *Groundwater Geochemistry*. CRC Press New York.

Deutsch, W.J. 1995. Metal Mobility at Landfills and Other Waste Disposal Facilities. Presented at First Symposium on the Hydrogeology of Washington State.

Deutsch, W.J., and K.M. Krupka. MINTEQA Geochemical Code: Compilation of Thermodynamic Database for the Aqueous Species, Gases, and Solids Containing Chromium, Mercury, Selenium, and Thallium. EPA document (submitted).

Peterson, S.R., C.J. Hostetler, W.J. Deutsch, and C.E. Cowan. 1987. MINTEQA User's Manual. NUREG/CR-4808. U.S. Nuclear Regulatory Commission. Washington DC.

Peterson, S.R., and W.J. Deutsch. 1987. Geochemical Reaction Modeling in Contaminant Migration Studies. Proceedings of the Conference on Solving Groundwater Problems with Models. National Water Well Association, Denver Colorado. February 10-12, 1987, pp 1353-1383.

Deutsch, W.J. and J.W. Thackston. 1986. Aquifer Restoration Considerations at Inactive Uranium Mill Tailings Sites. Proceedings of the Fourth Annual Hazardous Materials Management Conference. Atlantic City, New Jersey. June 2-4, 1986

Dupuy, J.R., W.J. Deutsch, J. Hilton, G. Rice, and J.W. Thackston. 1986. Water Resource Protection and the UMTRA Project: Three Case Histories. Proceedings of the Conference on Southwestern Ground Water Issues. National Water Well Association. Tempe, Arizona. October 20-22,

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1986.

Deutsch, W.J., L.E. Eary, W.J. Martin, and S. McLaurine. 1985. The Use of Sodium Sulfide to Restore Aquifers Subjected to In Situ Leaching of Uranium Ore Deposits. Proceedings of the National Water Well Association Western Regional Ground Water Conference. January 15-16, 1985, Reno, Nevada.

Deutsch, W.J., W.J. Martin, L.E. Eary, and R.J. Serne. 1984. Methods of Minimizing Ground-Water Contamination from In Situ Leach Uranium Mining - Final Project Report. NUREG/CR-3709, PNL-5319, Prepared for the U.S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, Richland, Washington.

Deutsch, W.J., N.E. Bell, B.W. Mercer, R.J. Serne, and J.W. Shade. 1984. Aquifer Restoration at In Situ Leach Uranium Mines. NUREG/CR-3104, PNL-4583, Prepared for the U.S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, Richland, Washington.

Deutsch, W.J., and R.J. Serne. 1984. Uranium Mobility in the Natural Environment: Evidence from Sedimentary Roll-Front Deposits. In Geochemical Behavior of Disposed Radioactive Waste ed. by G.S. Barney, J.D. Navratil, and W.W. Schulz. ACS Sym. Series No. 246. Am. Chem. Soc. Washington DC.

Sherwood, D.R., C.J. Hostettler, and W.J. Deutsch. 1984. Identification of Chemical Processes Influencing Constituent Mobility during In Situ Uranium Leaching. Proceedings of the Symposium on Practical Applications of Ground Water Models. Columbus, Ohio, August, 1984.

Blair, S.C., W.J. Deutsch, and L.D. Kannberg. 1984. Laboratory Permeability Measurements in Support of an Aquifer Thermal Energy Storage Site in Minnesota. Proceedings of the 25th Annual Rock Mechanics Symposium. June, 1984, Evanston, Illinois.

Deutsch, W.J., R.J. Serne, N.E. Bell, and W.J. Martin. 1983. Aquifer Restoration at In Situ Leach Uranium Mines: Evidence for Natural Restoration Processes. NUREG/CR-3136, PNL-4604, Prepared for the U.S. Nuclear Regulatory Commission by Pacific Northwest Laboratory, Richland, Washington.

Deutsch, W.J., E.A. Jenne, and K.M. Krupka. 1982. Computed Solid Phases Limiting the Concentration of Dissolved Constituents in Basalt Aquifers of the Columbia Plateau in Eastern Washington. PNL-4089, Pacific Northwest Laboratory, Richland, Washington.

Deutsch, W.J. 1982. Guidelines for Sampling and Analyzing Solutions from Aquifer Thermal Energy Storage Systems.

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PNL-4333, Pacific Northwest Laboratory, Richland,
Washington

Krupka, K.M., E.A. Jenne, and W.J. Deutsch. 1982.
Validation of the WATEQ4 Geochemical Model for Uranium.
PNL-4533, Pacific Northwest Laboratory, Richland,
Washington.

Deutsch, W.J., E.A. Jenne, and K.M. Krupka. 1982.
Solubility Equilibria in Basalt Aquifers: The Columbia Plateau,
Eastern Washington, USA. *Chemical Geology*, 36:15-34.

Deutsch, W.J. 1980. *Geochemical Modeling of the Nuclear
Waste Repository System - A Status Report*. PNL-3518.
Pacific Northwest Laboratory, Richland, Washington

Deposition Testimony During Preceding Four Years (no trial testimony during this time period)

1. Crystal Geyser Roxane Water Company v. Roger Womack, dba Quality Piping Systems, No. 313860 (Super. Ct., San Francisco County, Calif.).
2. Pennsylvania American Water Company v. Jack Rich, Inc., No. 3:99CV2135 (U.S. Dist. Ct., M.D.Pa.).

Compensation Description per agreement dated April 11, 2002

Mr. Deutsch has been retained to prepare an initial expert report, a rebuttal expert report (if requested), and to provide associated technical advice, with compensation based upon a rate of \$150 per hour devoted to providing these services. Mr. Deutsch is to be compensated at a rate of \$250 for preparation and delivery of testimony in deposition and at trial. Mr. Deutsch is also to be reimbursed at cost for his expenses incurred for travel, long distance telephone, lodging, and other such itemized expenses.